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Derived Insensitivity: Rule-Based Insensitivity to Contingencies Propagates through Equivalence

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Abstract

Rule-governed behaviours enable rapid acquisition of appropriate and often complex behaviour in novel contexts; however, this capacity can also make individuals insensitive to environmental contingencies. This problem may be exacerbated if rules propagate from one context to another through derived relational responding. Here we assessed whether insensitivity due to rule-following would transfer to stimuli that were never directly associated with that rule, by means of combinatorial entailment. Multiple reinforcement schedules (1A=VR8; 2A= DRL8) were initially presented to two groups, one receiving rules on how to behave to earn as many points as possible, the other not receiving any rule. The participants then completed a matching-to-sample task in which equivalence classes were trained in a one-to-many format (1A←1B→1C; 2A←2B→2C). Finally, the derived stimuli (1C and 2C) were presented in a second multiple-schedule task, where the associated schedules were reversed (1C= DRL8; 2C= VR8), without informing the participants. Results demonstrated that insensitivity transferred to the stimuli set in equivalence for the participants who received rules, while participants who did not receive any rule adapted quicker to the contingencies changes. Results are discussed in relation to behavioural variability and psychological inflexibility that contributes to the development and maintenance of psychological issues.

Derived Insensitivity: Rule-Based Insensitivity to Contingencies Propagates through Equivalence

1. Introduction

Rule-governed behaviour (RGB) is defined as behaviour (either verbal or nonverbal) under the control of verbal antecedents (Catania, 1991), that is, instructions or rules. RGB may be contrasted with contingency-shaped behaviour, which is under the control of direct contact with environmental stimuli and consequences. For example, a child putting on a woolly hat before going outside because she previously felt the cold biting her ears would be an instance of contingency-shaped behaviour, but a child performing the same behaviour because she was previously instructed and reinforced to do so by a parent would be an instance of RGB. Verbal antecedents represent an important source of control for human behaviour, not least because they allow for the transmission of behaviours across time and space and endow people with the ability to efficiently interact with new contexts without previous direct experience (Hayes, 1989). Transmission and the ability to efficiently interact with new contexts confer an adaptive advantage for rule-following (Monestès, 2016) where it would otherwise be potentially harmful to learn from direct experience (e.g. “don’t touch the stove or you’ll get burned”).

Rules differ on numerous dimensions, one being the extent to which the contingency between behaviour and environment is specified (Pelaez, 2013). Some rules are generic and versatile, prescribing behaviour independently of the context, and indeed often incarnate in well-known sayings or maxims (e.g. “honesty is the best policy” or “nice guys finish last”). Other rules describe precisely the context in which a behaviour should be emitted. Yet even in the latter case, the corresponding RGB may frequently appear in different contexts. For example, one can be taught that a heavy object should not be lifted without someone else’s help and then apply the same rule in other contexts, such as lifting a large but light and fragile object, or even in a more abstract way by disclosing a chronic illness or a shameful thought to a friend, since difficult thoughts and emotions can be evaluated as “heavy”. In other words, discriminative stimuli can be part of the contingency in which the rule is stated and the behaviour is learned, but totally different stimuli can signal the possibility for this rule-governed behaviour to be reinforced. Ultimately, the behaviour can appear across very different contexts.

The capacity for transposing RGB to contexts different from those in which the rule was learned is also tied to a well-documented and potentially maladaptive property of RGB, namely, insensitivity to contingencies. When following a rule, humans tend to be more sensitive to the socially mediated consequences of following the rule itself than to the direct consequences brought by the behaviours that appear when the rule is followed. In other words, humans tend to be more sensitive to the consequences of rule-following as a response class than to the consequences of specific instances of behaviour produced by following a rule (Catania, Shimoff, & Matthews, 1989). This tendency creates insensitivity to the immediate environmental contingencies and eases the transposition of the rule to contexts distant from those in which it initially appeared. Indeed, many experiments show that rule-governed behaviours are insensitive to changes in contingencies and that having learned one rule in one context, subjects routinely follow that rule in a new context, even when the new context provides no direct reinforcement for the behaviour in question (Baron & Galizio, 1983; Catania et al., 1989; Catania, Shimoff, & Matthews, 1990; Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986; Rosenfarb, Newland, Brannon, & Howey, 1992; Shimoff & Catania, 1998; Vaughan, 1989; Wulfert, Greenway, Farkas, Hayes, & Dougher, 1994).

This insensitivity to direct and short-term consequences of rule following is tied to the essence of verbal rules: they constitute abstractions of contingencies recurrent across contexts. Consequently, rule-following overtakes contexts’ specificities and helps to rapidly transfer previously adaptive behaviour to new contexts. However, should the behaviour in question in fact be maladaptive in a new context, RGB can be particularly deleterious by resulting in the perseverance of behaviour despite adverse consequences.

Thus, the two advantageous properties of RGB, namely insensitivity to direct and short-term consequences and transposition to distant and different contexts, can give rise to problematic behaviours insensitive to immediate consequences and maintained by hypothetical long-term ones. Such problematic behaviours have been suggested as central to the development of psychological issues (Törneke, Luciano, & Salas, 2008).

While stimulus generalization can explain the transfer of RGB across contexts with common characteristics (lifting a fragile object in our earlier example), this is not the case when contexts do not share any topographical properties (disclosing a shameful thought in our earlier example). Instead, when symbolic properties are involved, Relational Frame Theory (RFT; Hayes, Barnes-Holmes, & Roche, 2001) proposes that arbitrarily applied relational responding provides a more plausible explanation of RGB transfer.

Three key properties of arbitrarily applied relational responding are pertinent here. Firstly, when a relationship is learned between a stimulus A and a stimulus B, verbally able human beings will derive a relationship between B and A ("mutual entailment"). Secondly, when a stimulus A is related to a stimulus B and then to a stimulus C, B and C are then mutually related without having ever been paired together directly ("combinatorial entailment"). Finally, when several stimuli are related, changes in the functions of one of these stimuli can result in changes in the functions of other stimuli (Ramnerö & Törneke, 2008) through transfer or transformation of function[1].

Many studies have demonstrated transfer of function across stimuli that do not share any physical property, but are verbally set in equivalence, even when these stimuli have never been directly associated (Steele & Hayes, 1991). Additionally, Transformation of function has been implicated in many psychological processes, such as avoidant behaviours (Dymond, Roche, Forsyth, Whelan, & Rhoden, 2008), causal efficacy judgments (Dack, McHugh, & Reed, 2009), conditioned suppression (Greville, Dymond, Newton, & Roche, 2014), and thought suppression (Hooper, Saunders, & McHugh, 2010). However, no study has yet investigated whether RGB-induced insensitivity to contingencies will be transposed to a new context as a result of arbitrarily applied relational responding. Hayes, Thomson and Hayes (1989) have previously demonstrated transfer of RGB via arbitrarily applied relational responding but did not test for the transfer of insensitivity, as the established rule that was transferred in their experiments remained appropriate for the new context. Their design therefore precluded the researchers assessing any inappropriate persistence of behaviour.

In the present study, we examined whether insensitivity to contingencies due to RGB would generalize to new contexts as a consequence of derived relational responding. If so, then having established RGB in the presence of a first stimulus, derived insensitivity should

1 Throughout this article, we use the word “transformation” of function when describing RFT in a broad context, and “transfer” of function when referring to relations of equivalence, such as those tested in the present study. Transfer of function represents a special case of transformation of function. Indeed, in a relation of equivalence, the function of a stimulus A transforms the function of a stimulus B in a way that both stimuli share the same functions (before set in equivalence with A, B may have other functions, or no function at all). The transformation is more evident with other relational frames (e.g. opposition). For example, if A is the opposite of B and A acquires appetitive properties, the function of B is transformed to become aversive. As it may be confusing to speak of transformation when stimuli share the same function, the term “transfer” is preferred when referring to relations of equivalence.

manifest in the presence of a new stimulus that is arbitrarily related to the first via an equivalence class, even if these stimuli have never been directly associated and the rule is not stated in presence of this new stimulus. In other words, we hypothesized that insensitivity due to rule-following would transfer through stimulus equivalence to stimuli never directly associated with the rule.

To test this hypothesis, we initially presented multiple reinforcement schedules in the presence of nonsense-word discriminative stimuli (1A = Variable Ratio 8 [VR8]; 2A = Differential Reinforcement of Low rate 8 s, **[**DRL 8 s]) to two groups of participants, one receiving rules on how to behave to earn as many points as possible on each schedule, the other not receiving any rule. These schedules usually produce very different patterns of behaviour, with high rates of responses for VR and low rates for DRL. In a second task, equivalence classes (1A = 1B = 1C; 2A = 2B = 2C) were taught to the participants by means of a matching-to-sample equivalence training task. Finally, we tested for insensitivity to changes in contingencies transferred to stimuli never associated with the rules by presenting 1C and 2C (the derived stimuli) but with the associated schedules reversed (i.e. 1C= DRL 8 s; 2C= VR 8) and without informing the participants. Our hypothesis is that a participant whose behaviour is rule-governed would be insensitive to contingency changes in this last task and would exhibit higher rates of responses for 1C (DRL) and lower rates for 2C (VR) stimuli, despite such patterns of responding being sub-optimal following the schedule inversion.

In addition, we also considered that individual differences might play a role in participants' perseverating in rule-following. Specifically, the concept of cognitive fusion -- the tendency for behaviour to be overly regulated and influenced by cognition (Gillanders et al., 2014) – has previously been implicated in behavioural rigidity (e.g. McCracken, DaSilva, Skillicorn, & Doherty, 2014) and thus could contribute to perseverative behaviour. Accordingly, we measured cognitive fusion using a questionnaire. We predicted that participants with higher cognitive fusion scores (regardless of group) would take longer to adapt their behaviour following the change in schedules.

2. Method and materials

2.1 Participants and Design

One hundred and sixty five students (144 females, 20 males, 1 undisclosed) from Grenoble Alpes University took part in the study in exchange for course credit. The mean age of the participants was 20.40 (*SD* = .19) years. The study adopted a mixed design with subjects randomly allocated to either the Rule Provided (RP) or the No Rule Provided (NRP) group as the between-subjects variable. Performance in Task 1 compared to Task 3 (see 2.3 Procedure) served as the within-subjects variable while CFQ score (see 2.2 Apparatus and Materials) was a covariate. The dependent measures were number of schedules taken to reach criterion and number of responses in the first schedule of each type in Task 3 (see 3.1 Summary of analysis for further details). Of the 165 participants initially recruited, 87 successfully completed the experiment; 46 in the RP group (41 females, 4 males, 1 undisclosed, mean age 20.66 years), and 41 in the NRP group (34 females, 7 males, mean age 20.07 years).

2.2 Apparatus & Materials

The experiment was conducted using a computer program developed in Python™ version 2.7.9 and took place in a computer lab using a 14 inch HP laptop (1920 * 1080 screen resolution). Participants also completed the Cognitive Fusion Questionnaire (CFQ, Gillanders et al., 2014; French version Dionne et al., 2016), a brief self-report measure which assesses fusion with thoughts and the tendency for an individual’s behaviours to be overly governed by thoughts rather than by direct consequences. The CFQ consists of 7 items (for example “I tend to get very entangled in my thoughts") answered on a 7-point Likert scale, from 1 (never true) to 7 (always true), with greater scores indicating more cognitive fusion.

2.3 Procedure

Participants were initially presented with an information sheet followed by a consent form to confirm their agreement to participate. After they completed the CFQ, the experimenter launched the program and participants worked their way through Tasks 1, 2 and 3 as described below, with instructions for each task being provided on-screen and by the experimenter.

1) Task 1 - Schedules Learning

In this task, participants had to score as many points as possible on multiple schedules. Two nonsense words (1A and 2A, see Table 1 for words used) appeared alternatively on the computer screen for 30 s each. Points could be scored by pressing a button on the screen with the mouse, according to the reinforcement schedule associated with each nonsense word: 1A was governed by a VR8 schedule[2] and 2A by a DRL8 s schedule[3]. The running points score was presented on the screen and immediately updated when a point was scored. The stimulus presented first was counterbalanced across participants. If assigned to the RP group, participants were explicitly told to "press often when you see [stimulus 1A] and press less often when you see [stimulus 2A]" (note that participants saw the particular nonsense words designated as these stimuli). In the NRP group, no instructions were given regarding the

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[2] One point earned after an average of 8 presses on the button. Participants could earn a point after a number of successive presses, the precise number required varying from trial to trial from 1 to 15 (thus tending to average towards 8 over repeated trials).

[3] One point earned for the first press after an 8-s interval, provided no additional presses were made during that interval. Participants could earn a point if they waited at least 8 s since their last press before pressing the button again. If, however, they pressed before the end of this interval, a new interval started and they had to wait another 8-s delay before their press would be reinforced by a point.

behaviours to emit apart from the fact that one can potentially earn points by clicking the button. This task ended when participants emitted a minimum of 80 responses on stimulus 1A (VR8) and a maximum of 30 responses on stimulus 2A (DRL8), twice successively for each schedule, thus demonstrating that their behaviour adapted to the schedules. In order to reduce the potential for participants to reach the criterion by a fluke, each stimulus was presented twice before participants' responses began to count towards criterion. Each stimulus was thus presented a minimum of four times.

2) Task 2 - Equivalence Training

An equivalence training and testing program was then used for participants to learn relations between the stimuli (see Table 1).

Table 1

In each training trial, a nonsense word was first presented as a sample in the centre of the screen and remained on screen until clicked with the mouse. Three other nonsense words were presented subsequently (one in each corner of the screen, the fourth corner remaining blank; the positions of the blank and the three nonsense words were randomised across trials). Participants were required to select which stimulus they thought matched the sample by clicking on it with the mouse, at which point the trial ended and a new one began after a 500-ms interval. Participants received training blocks of 12 trials, where stimuli 1B, 2B, and 3B[4] were each presented as the sample four times in total; on two of the four occasions being

[4] A third stimulus class was also trained for equivalence, with one member of this class (3C) then presented in Task 3. This stimulus was not associated with a reinforcement schedule, as no member of this class was trained in Task 1, but was instead presented as a distractor. These distractors were used to prevent participants from easily working out which stimulus was attached to each reinforcement schedule in Task 3 through a process of elimination.

followed by 1A, 2A (and 3A) as the comparison stimuli, and on two occasions being followed by 1C, 2C (and 3C). Equivalence classes were then trained in a one-to-many format (1A$\leftarrow$1B$\rightarrow$1C; 2A$\leftarrow$2B$\rightarrow$2C). Corrective feedback was provided; for example, “Correct” was displayed on selecting 1A with 1B as the sample, but “Wrong” was displayed on selecting 2B, such that equivalence relations were trained between stimuli A and B, and between stimuli B and C. No direct relationship was trained between A and C. If the appropriate directly trained and derived relations emerge, according to the principles of relational frame theory, then stimulus classes will become established between the stimuli of class 1, between the stimuli of class 2 (and between the stimuli of class 3), such that members of these stimulus classes become functionally equivalent and interchangeable. Participants were subsequently given 12 test trials in which a random subset of the relations that were not directly trained was presented (e.g. 1C might be presented as the sample and 1A, 2A, and 3A presented as the comparisons). No feedback was given during this phase, but participants’ responses were monitored. If the participant obtained 80% correct responses or above, then the program ended and the participant proceeded to the next phase; if not, the training and testing process repeated until this criterion was reached.

3) Task 3 - Derived Insensitivity Test

Task 3 involved the same basic procedure as Task 1 but using stimuli 1C, 2C, and 3C instead of 1A and 2A. Reinforcement schedules were reversed such that 1C corresponded to the DRL 8 s schedule and 2C corresponded to the VR 8 schedule (response to stimulus 3C yielded no points). Similarly to Task 1, Task 3 ended after each stimulus had first been experienced twice, and then subsequently when participants made a minimum of 80 responses for each of two successive presentations of 2C (VR 8) and a maximum of 30 responses for each of two successive presentations of 1C (DRL 8 s).

3. Results

3.1 Summary of Analyses

The measure of key importance was the swiftness with which participants adjusted to the inverted contingencies during the Derived Insensitivity task (Task 3). Because both the Schedules Learning (Task 1) and Derived Insensitivity (Task 3) tasks required participants to reach a criterion in order to conclude the task, the number of schedule presentations taken to reach this criterion functioned as the primary dependent variable. A greater number of schedule presentations taken to reach criterion suggests a weaker sensitivity to contingencies. Accordingly (for participants who completed the whole experiment), number of schedule presentations was compared between RP and NRP groups in Task 1 (stimuli 1A and 2A) and Task 3 (stimuli 1C and 2C) using a 2×2 mixed ANOVA, with RP vs NRP groups as the between-subjects factor and Task (1 vs 3) as the within-subjects factor. CFQ score was included as a covariate. These results are detailed in section 3.4.

As a second dependent measure, we also examined and compared response rates during the first presentation of each schedule type (VR8 and DRL8 s) in Task 3. It is possible, given that each schedule lasted for 30 s, that participants adapted to the switch of schedules rapidly, even within the first schedule itself. In this case, number of overall schedules experienced may not serve as a useful comparison, but response rates during the first presentation of each schedule may reveal important differences between groups. Again, a 2×2 mixed ANOVA (with RP vs NRP group as the between-subjects factor and VR8 vs DRL8 s as the within-subjects factor) was used to assess differences in response rates during the first presentation of each schedule type in Task 3. These results are detailed in section 3.5.

Finally, because each task required the participant reach a criterion in order to end the task (and allow the participant access to the next one), individuals less sensitive to contingencies, and/or more rapidly subject to boredom, have greater probability of leaving the experiment before completing it. Therefore, in order to screen for a potential non-random distribution of drop-outs among groups, and to ensure that the groups' results are not differentially influenced by such factors, a comparison of the number of schedules and trials before drop-out was first conducted across groups for each task, as detailed below in sections 3.2 and 3.3.

3.2 Comparisons of drop-outs between groups

The number of participants in each task is presented in Figure 1.

Figure 1

Fifteen participants from the RP group and 35 from the NRP group withdrew during Task 1. Participants in the RP and NRP groups did not differ significantly on the mean number of schedules they experienced before abandoning the experiment (52.87, *SD* = 18.66, and 57.17, *SD* = 14.41, respectively, $t(48) = -.80$, $p > .05$, $d = 0.26$. Eight participants from the RP group and seven from the NRP group withdrew during Task 2. The mean number of schedule presentations (1A + 2A) for the RP group and for the NRP group participants who did not complete Task 2 did not differ significantly (23.50, *SD* = 14.68, and 29.43, *SD* = 12.07), $t(13) = -.86$, $p > .05$, $d = .44$. Nine participants from the RP group and four participants from the NRP group did not complete Task 3. The mean number of trials needed to reach the criterion set in Task 2 was, respectively, 1.78 (*SD* = 1.40) and 2.75 (*SD* = 1.71) for the RP group and the NRP group participants who did not complete Task 3; this difference again was not significant, $t(11) = -1.00$, $p > .05$. Finally, there was no significant difference in CFQ scores between participants who did not complete the whole experiment and those who did, with respective mean scores of 24.30 (*SD* = 7.41) and 25.49 (*SD* = 8.45), $t(158) = -.94$, *p* > .05. These data allow us to conclude that there were no initial differences between the groups of participants who completed the whole experiment.

3.3 Number of trials to reach criterion during Task 2 (Equivalence Training)

The results from the Equivalence task are not central to this study but are presented here for the sake of completeness. The number of trials in the training and testing phases of this task was fixed, but a minimum criterion of 80% correct responses was required to access Task 3; if criterion was not reached, participants had to repeat the training and testing cycle. Hence, all participants who accessed Task 3 demonstrated combinatorial entailment. The mean number of training and testing cycles was 2.36 (*SD* = 1.13) for the RP group and 2.15 (*SD* = 1.09) for the NRP group. The difference between these means was not significant, $t(86) = .87$, $p > .05$, $d = .19$). The groups of participants thus took a comparable number of cycles to learn equivalence between the stimuli.

3.4 Comparison between groups of the number of schedule presentations during Task 1 (Schedules Learning) and Task 3 (Derived Insensitivity)

Only data from participants who completed the entire study were considered from hereon. One participant in the RP group was an outlier in terms of the number of trials experienced during Task 1 (51; +7 *SD*) and was not included in the analyses. The mean age for RP (20.57, *SD* = 3.39) and NRP (20.07, *SD* = 1.74) groups did not differ significantly, $t(81) = .85$, $p > .05$, $d = .19$. The sex ratio did not differ significantly between groups $t(81) = 1.38$; $p < .05$ with respectively 86.7% and 82.9% females in the RP and NRP groups; also, the CFQ scores did not differ significantly between RP and NRP groups ($t_{(72)} = .70$, $p > .05$, $d = .17$), with respective scores of 26.38 (*SD* = 9.48) and 24.91 (*SD* = 7.78). Groups were thus comparable at baseline.

Table 2 shows the mean number of responses emitted and points scored by participants who completed the tasks under each schedule for each group during Schedules Learning (Task 1) and Derived Insensitivity (Task 3).

Table 2

Figure 2 shows the mean number of schedules experienced by each group, both RP and NRP, in both Task 1 and Task 3.

Figure 2

A 2×2 mixed ANOVA found no significant effect of either group $F(1,82) = 0.27$, $p = 0.60$, $\eta_p^2 = .003$), or task ($F(1,82) = 3.20$, $p = 0.077$, $\eta_p^2 = .038$) in isolation, but a significant interaction between group and task, $F(1,82) = 15.56$, $p < 0.05$, $\eta_p^2 = .159$). In Task 1, the mean number of schedule presentations (1A + 2A) before reaching the learning criterion was, respectively, 10.87 ($SD = 5.56$) and 16.54 ($SD = 8.31$) for RP and NRP groups. Follow-up tests confirmed a significant difference between the groups $t(84) = -3.68$, $p<.05$, $d = .80$, with the RP group participants reaching the learning criterion more quickly, as expected given that they received rules on how to maximise the number of points won, and consistent with our hypothesis. In Task 3, the mean number of schedules presented (1C + 2C) before reaching the learning criterion was, respectively, 13.82 ($SD = 10.43$) and 9.88 ($SD = 6.32$) for the RP and NRP groups. Follow-up tests confirmed a significant difference between the groups, $t(84) = 2.14$, $p < .05$, $d = .46$. Thus, in what is the key finding of this study, the RP group adapted more slowly to the inverted reinforcement schedules than the NRP group, showing the hypothesized insensitivity to contingencies. To screen for any influence of the number of presentations during Task 1 on results in Task 3, an ANCOVA was run, with group as the independent variable, number of schedules presented in Task 3 as the dependent variable, and number of schedules presented in Task 1 as the covariate. No significant effect of number of presentations in Task 1 was found, $F(1,83) = 0.352$, $p = .554$, $\eta_p^2 = .004$, indicating that exposure required to reach criterion in Task 1 did not influence subsequent behaviour in Task 3. A significant effect of group on the results in Task 3, $F(1,83) = 4.65$, $p < .05$, $\eta_p^2 = .05$, was found, providing additional confirmation that the RP group participants needed more exposure to adjust to the reinforcement contingencies and complete the task.

3.5 Comparison of the number of responses for the first presentation of each schedule during Task 3 (Derived Insensitivity Task)

Mean total responses in the first schedule of each type (VR8 and DRL8 s) in Task 3 are shown in Figure 3 for both RP and NRP groups.

Figure 3

A 2×2 mixed ANOVA found no significant effect of group, $F(1,82) = 0.27$, $p = 0.605$, $\eta_p^2 = .003$, but found a significant effect of schedule type $F(1,82) = 3.20$, $p = 0.077$, $\eta_p^2 = .038$, confirming that response rates were higher in the VR8 schedule than in the DRL8 s schedule. This finding might, at first glance, appear to undermine our finding of derived insensitivity, as it suggests participants were able to quickly calibrate their responding to the schedules, emitting more responses to the VR8 rather than the DRL8 s schedule, even after the inversion of the schedule-stimulus association. However, a significant interaction was also observed between group and task, $F(1,82) = 15.561$, $p < 0.05$, $\eta_p^2 = .159$, confirming that participants in the RP group emitted, on average, fewer responses in the VR8 schedule and more responses in the DRL8 s schedule than the NRP group participants, indicating that they were slower to adapt their responding and thus showed less sensitivity to the contingencies.

3.6 Influence of CFQ score

Contrary to our predictions, there was no significant influence of CFQ score as a covariate either on number of schedules experienced $F(1,82) = 0.27$, $p = 0.605$, $\eta_p^2 = .003$, or on response rate, $F(1,82) = 0.89$, $p = 0.398$, $\eta_p^2 = .011$.

4. Discussion

In the present experiment, we asked if the insensitivity observed in the case of rule-following would transfer to stimuli never directly associated with the rule, by means of combinatorial entailment. Participants first learned two schedules of reinforcement in a multiple schedules design (1A = VR8, 2A = DRL8 s), either by exploration or via rules given by the experimenter. As previously reported (Hayes, 1989), participants provided with accurate rules adjusted more quickly to the contingencies. The stimuli associated with each schedule (1A and 2A) were then set in equivalence with two other stimuli through combinatorial entailment (i.e., derived equivalence between 1A and 1C, and between 2A and 2C). Finally, when tested with the stimuli set in equivalence and never associated with the rule (1C and 2C), participants who initially received a rule continued to follow it (i.e., they were slower to adjust to the new contingencies), despite schedule inversion and a concomitant decrease in reinforcement.

These findings are important for a number of reasons. Firstly, they add to the literature on rule-governed behaviour by showing that RGB can easily transfer to distant and abstract contexts, providing that the new context was set in a relationship, even indirectly, with the one in which the RGB initially appeared and was reinforced. In other words, our results suggest that RGB represents such a robust response class that instances of behaviours under the control of a rule can appear in contexts very different from those in which they were initially taught, even despite being non-adaptive in the new context.

Secondly, the present results add to the knowledge base on transformation of function. To date, transformation of function by means of combinatorial entailment has been shown with many different stimuli and in various relations (see Dymond & Roche, 2013, for a review). In the current study, the stimuli presented when rule following was reinforced can be considered as analogues of verbal stimuli (Hayes & Hayes, 1989; Hayes, Thompson, & Hayes, 1989): they were not the rule itself but stood for it. Consequently, our experiment shows that stimuli in the context of verbal utterances can acquire verbal functions and that these functions acquired by analogues of verbal stimuli can be transferred to arbitrarily related stimuli, one of these functions being insensitivity to changes in contingences.

Finally, the present results can help understand chronic aspects of many different psychological issues in terms of variability of behaviours. Recently, Hayes & Monestès (in press) proposed that low functional variation associated with high formal variation of behaviours defines psychological inflexibility, a central component for several psychological conditions (see Boulanger, Hayes, & Pistorello, 2010, for a review). In this view, people suffering from psychological issues try to reach a restricted range of functions (for example “I must not feel anxious”) by all means (drinking alcohol, avoiding incertitude, etc.), and often by rigidly following the same rule, regardless of the context or consequences. Conversely, in the study of emotion regulation, a proposition to consider is that no regulation strategy can be considered definitely efficient or deleterious, but that strategy efficiency is dependent on context (Aldao, 2013); hence, the availability of many different emotion regulation strategies and the capacity to adjust to context and consequences may protect against psychological issues (Aldao & Nolen-Hoeksema, 2012).

Consequently, perpetuation and propagation of behaviours with adverse consequences have to be explained to understand the development, maintenance and potential treatment of psychological issues. In this regard, RGB's insensitivity to contingency change could explain the surprising perseverance of clients' maladaptive behaviours when facing adverse consequences for these behaviours. Indeed, insensitivity in the case of RGB has been observed in various psychological issues. For example, adolescents with high levels of depression show problematic rule following in the case of inaccurate rules (McAuliffe, Hughes, & Barnes-Holmes, 2014), and clients presented with delusions tend to show more insensitivity to contingency changes than control participants in environments where rules were formerly accurate and RGB was reinforced (Monestès, Villatte, Stewart, & Loas, 2014). The rigid pursuit of a unique function (for example, never feeling sad) in very different, but symbolically related contexts, and ultimately the spreading of maladjusted behaviours across the behavioural repertoire, can be the product of the insensitivity transfer between arbitrarily related stimuli, such as observed in the present study. Because relational responding is arbitrarily applicable, any stimulus can stand for any rule and set the condition for rule-governed behaviours to appear, even in contexts where they ultimately become maladaptive or problematic.

Although the results of the present study help us to understand the propagation of maladaptive behaviours across symbolically related contexts, it is important to recognise potential limitations of the study. One cause for concern is the high dropout rate across the different tasks (30% in the 1st task, 13% in the 2nd task, and 13% in the last task, for a total of 47% of dropout from the initial population). This dropout rate may reflect a floor effect due to the complexity of the tasks and raises questions regarding the characteristics of the participants who completed the whole experiment. Inflexibility can be hypothesised as related to perseverance because it prevents adjustment to contingencies and encourages the perpetuation of the same behaviours. The learning criteria set for the different tasks may have selected the more perseverant participants, who continued the experiment for a longer time, and who might be presenting with more inflexibility. Also, the learning criteria may have selected participants better at deducing and following rules or at deriving relations between abstract stimuli, and who thus completed all the tasks quicker, hence preventing boredom. Our analysis of the results for the participants who abandoned the experiment before completing all the tasks showed that they were equally distributed across the groups that did or did not receive a rule. This observation supports the reliability of our results concerning the propagation of rule-based insensitivity through derivation. Nonetheless, it would be interesting to lower the learning criteria, or to propose an incentive fee to the participants, to ensure that a larger number of them complete the whole experiment.

The context in which the experiment was run, notably the fact that participants were students, can represent another limitation of this research. Students as a population are typically well-versed in following instructions, to complete exercises and other academic work for instance. In the present experiment, an extensive prior learning history of complying with instructions in our participants could have increased their susceptibility to rule-based insensitivity to contingencies. This over-compliance with rules may not have had any effect on the propagation of insensitivity to arbitrarily related stimuli (instructions were minimal for this task), but the test of such a specific population may have over-estimated the existence of insensitivity in case of rule-following. In order to justifiably generalise these findings, tests of the present procedure with diverse groups of participants are warranted. Also, subsequent studies would benefit from initial screening for rule following inclination and schedule learning sensitivity to test for potential effects on transfer of functions and individual modes of adjustment to contingency change in the case of RGB.

Finally, if a more economical experimental paradigm could be designed, it may be worthwhile to investigate transfer of insensitivity in the case of rule-following with people suffering from various psychological issues. Indeed, derived insensitivity by means of combinatorial entailment, such as observed in the present study, represents a potential candidate for a mechanism that underlies such issues. In such conditions, resolving the puzzle of behaviour rigidly emitted in different contexts despite adverse consequences may be seen as a crucial part of developing a treatment and recovery plan, a direction currently taken by different therapeutic propositions grounded in Relational Frame Theory (Hayes, Monestès, & Wilson, in press; Villatte, Villatte, & Hayes, 2016).

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Table 1. Relations Directly Taught Within Equivalence Training

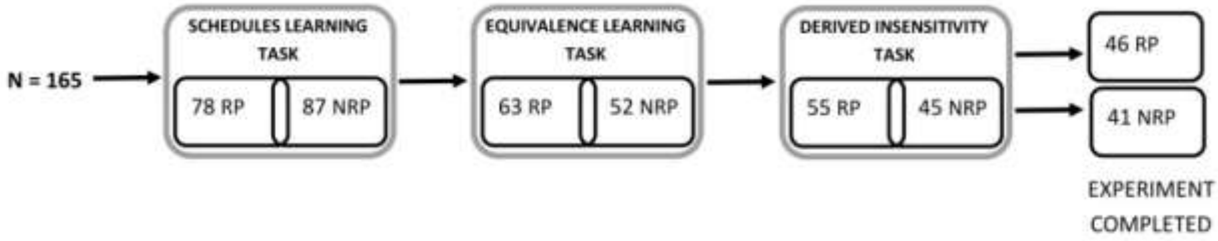
	Stimuli A		***Stimuli B***		***Stimuli C***
1 Class	Boceem	←	Gedeer	→	Surtel
2 Class	Remond	←	Murben	→	Matsel
3 Class	Lewoly	←	Cipher	→	Jandeg

Note. Arrows indicate the equivalence relations directly taught and reinforced during the training part of the Equivalence Learning task, corresponding to a one-to-many format training of equivalence classes.

Table 2. Mean number (*SD*) of points and responses for each schedule and each group during Schedules Learning (Task 1) and Derived Insensitivity (Task 3) tasks, for participants who completed all the tasks

TASK	**Task 1: Schedules Learning**				**Task 3: Derived Insensitivity**			
SCHEDULE / GROUP	**VR8**		**DRL8**		**VR8**		**DRL8**	
	Points	**Responses**	**Points**	**Responses**	**Points**	**Responses**	**Points**	**Responses**
RULE-PROVIDED GROUP	18.56 (2.61)	154.62 (20.12)	4.34 (4.31)	31.01 (19.18)	5.85 (4.00)	35.05 (33.86)	15.96 (5.00)	133.03 (38.35)
NO RULE-PROVIDED GROUP	15.17 (4.01)	131.01 (33.96)	4.72 (2.25)	45.21 (28.94)	6.68 (1.65)	20.97 (13.20)	18.11 (1.96)	155.44 (15.03)

Figure 1: Number of participants from the Rule Provided and the No Rule Provided groups who completed each task



Note. RP = Rule provided group; NRP = No rule provided group

Figure 2: Evolution of mean number of schedules presentation (class 1 + class 2) before reaching criterion from the Schedules Learning task to the Derived Insensitivity task for the Rule Provided and the No Rule Provided groups

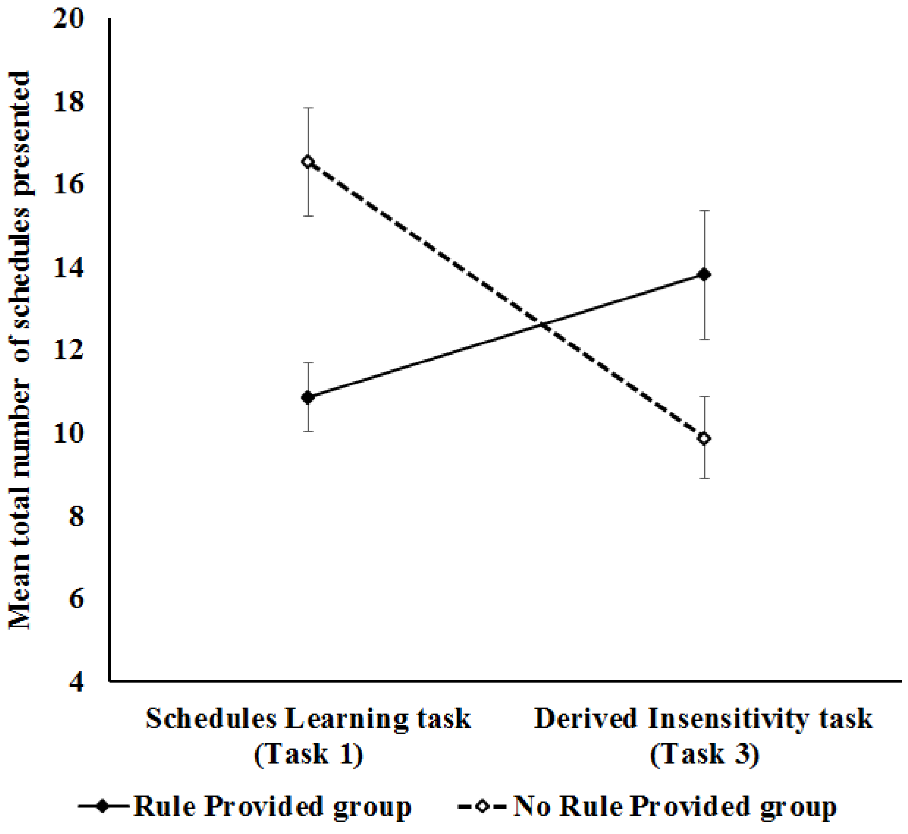


Figure 3: Mean number of responses emitted for the first presentation of each schedule in Derived Insensitivity task (Task 3) (after inverting the schedules)